Nanocomposite Strain Sensors

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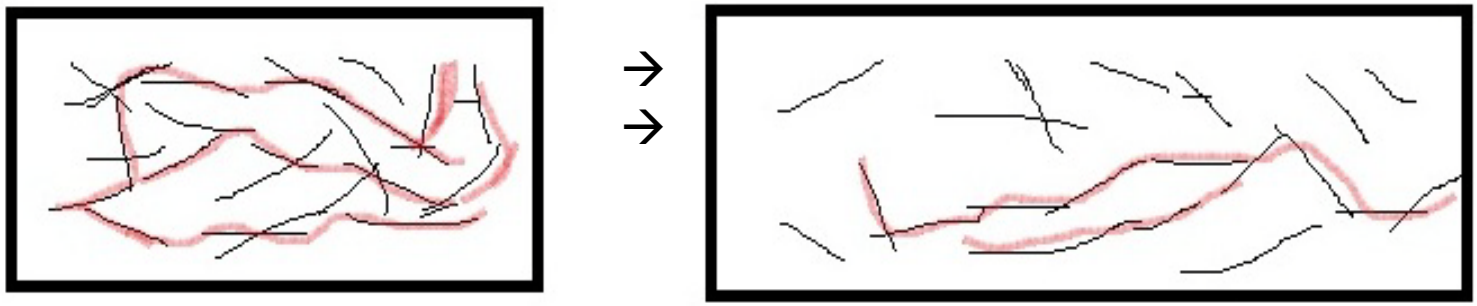
Motivation

- To introduce a lighter, lower cost strain sensor.
- Versatility – a wide range of applications from aerospace to structural
- To take a fresh look at strain sensors and see where there is opportunity for alteration.

Measuring Strain

- Measure conductivity
- Apply strain
- Conductivity decreases
- Strain can be interpreted as a function of conductivity



Outline

- Introduction
  - Literature review and comparative analysis
- Materials overview
  - Fabrication process
- Data & Results
  - Examination of past and recent data
    - Issues and trends
- Conclusions

Introduction

The research is on strain sensors that are:

- Lighter
- Less expensive
  - Carbon Nanotubes (CNTs) vs. Vapor-grown Carbon Fibers (VGCFs)
    - SWCNTs cost ~$80/gram vs. $5-6/gram[1]

1. http://www.cheaptubes.com/carbon-nanotubes-prices.htm#Multi_Walled_Nanotubes_Prices

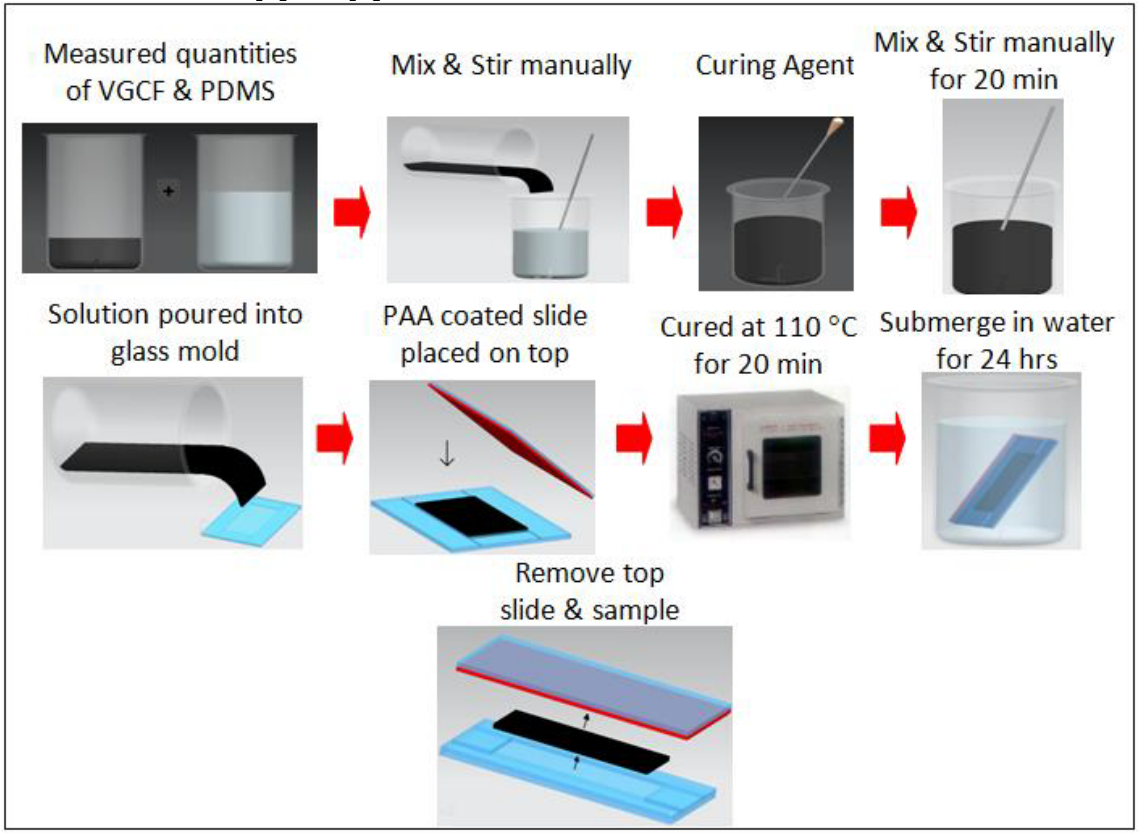
Carbon nanotubes (CNTs) vs. Vapor Grown Carbon Fibers (VGCFs)

- Similar mechanical and electrical properties
- Sizes of VGCFs can vary from a few nm (similar to CNTs) to about ten microns.[2]
- Comparable geometry
  - High aspect ratio
  - 'Nanofiber' designation for VGCFs (diameter is between 10 and 100 nm) and the presence of a central hollow core.[2]

2. Endo, Morinobu, and M. S. Dresselhaus. "Nanostructures Seminar Series at MIT." MIT Nanostructures Lab, 2003. Web. 11 Mar 2010. <http://web.mit.edu/tinytech/Nanostructures/Spring2003/MDresselhaus/i789.pdf>.

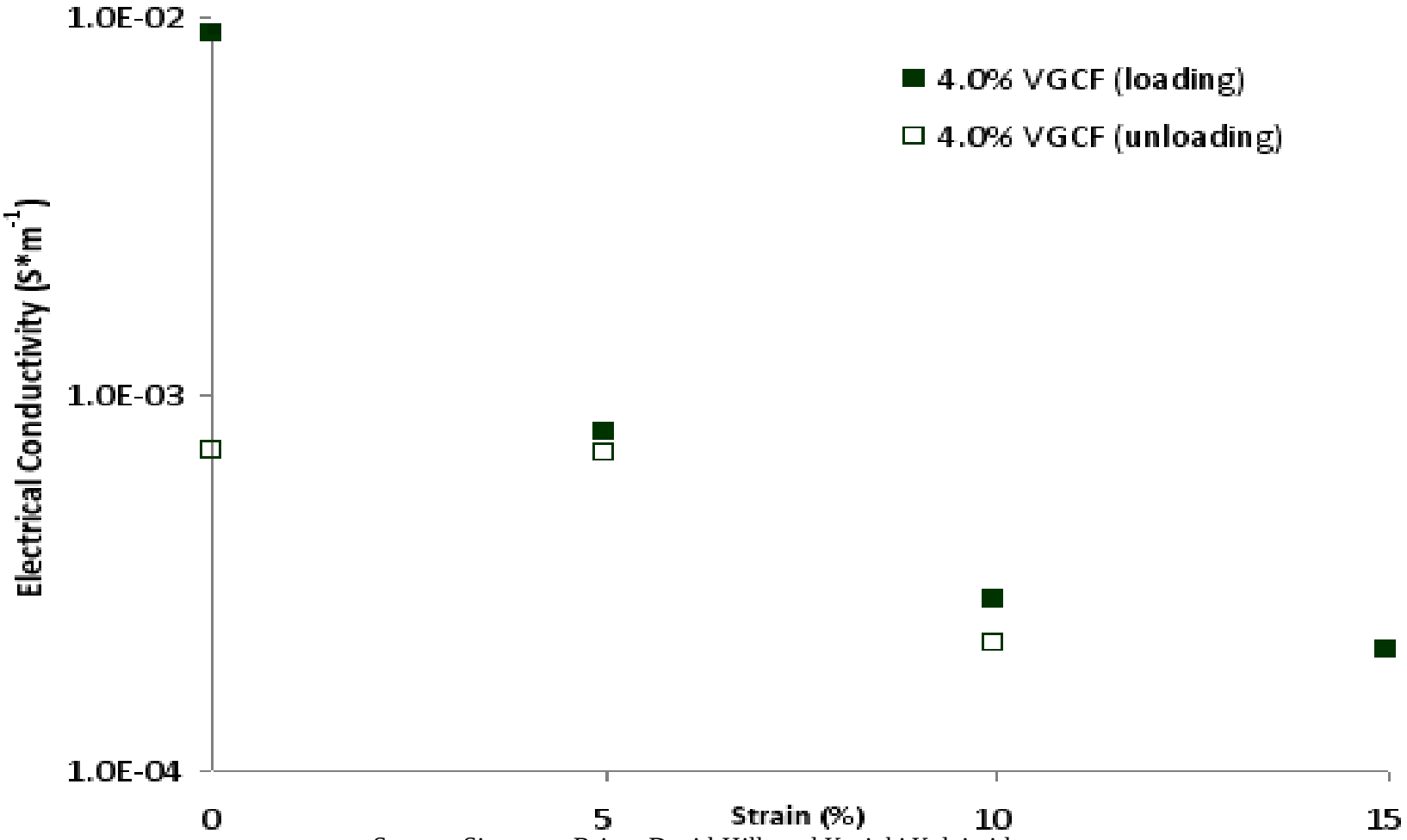
Materials Overview

- Vapor-grown carbon fibers (VGCF)
- Polydimethylsiloxane (PDMS)
- Curing agent



Source: Simpson, Brian, David Hill, and Kyriaki Kalaitzidou. "Manufacturing and Characterization of Nano-Composite Linear Strain Sensors." *ANTEC Conference 2009*. (2009): Print.

Effect of Strain on Conductivity for10:1, 4% VGCF



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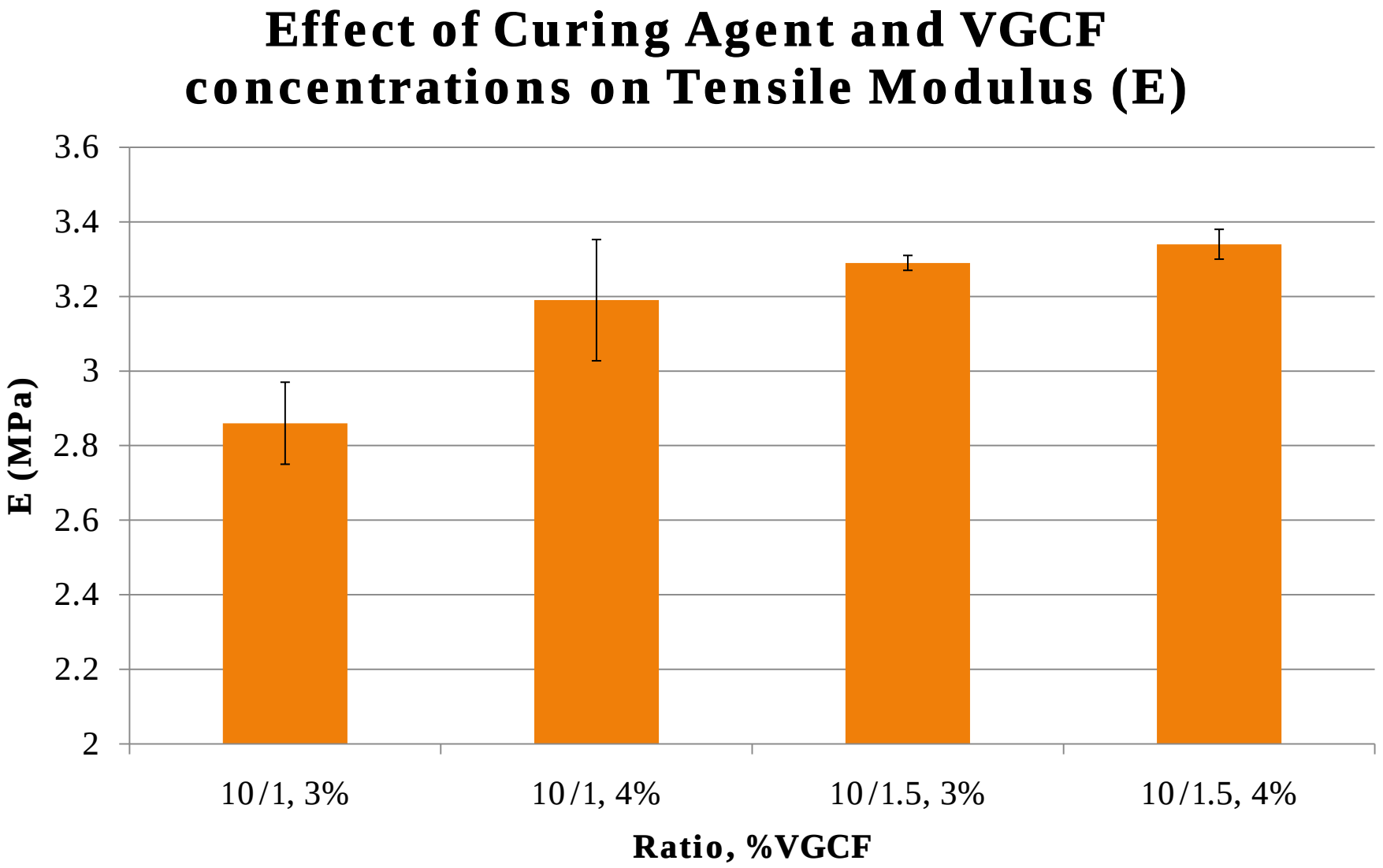
Possible Solutions

- Change the ratio of base to curing agent
- Past research was with 10:1, with varying percentages of VGCF from 1.5 – 4 wt. %.
  - 10:1
  - 10:1.5
  - 10:2
    - 3 and 4 wt. % VGCF

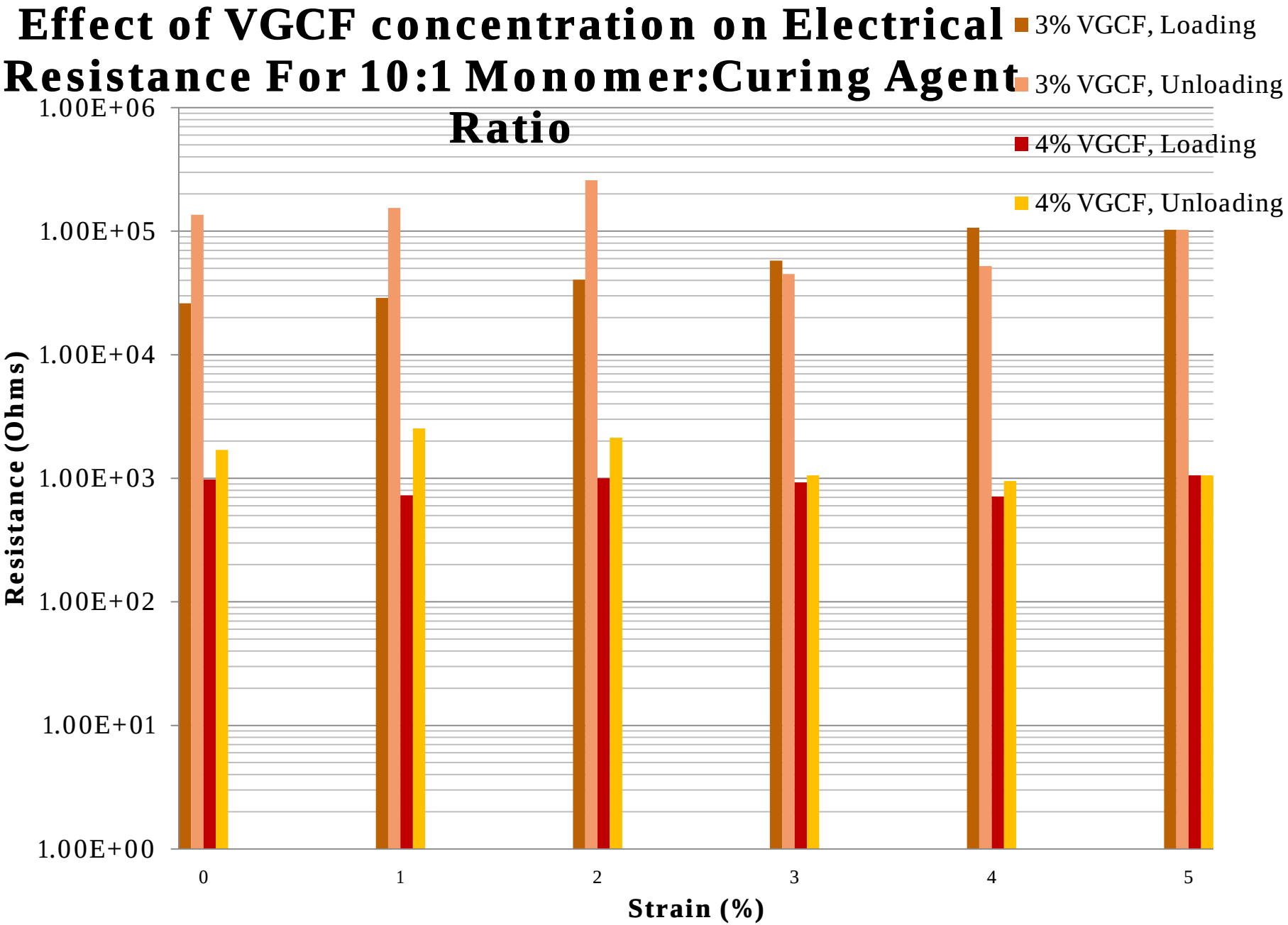
Testing

- Tensile testing (Dynamic mechanical analysis)
  - Dimensions: 20 mm x 6 mm x 1.75 mm
  - Samples strained at 1%/min
  - Max 25%
- Conductivity testing
  - Strain applied and conductivity is measured

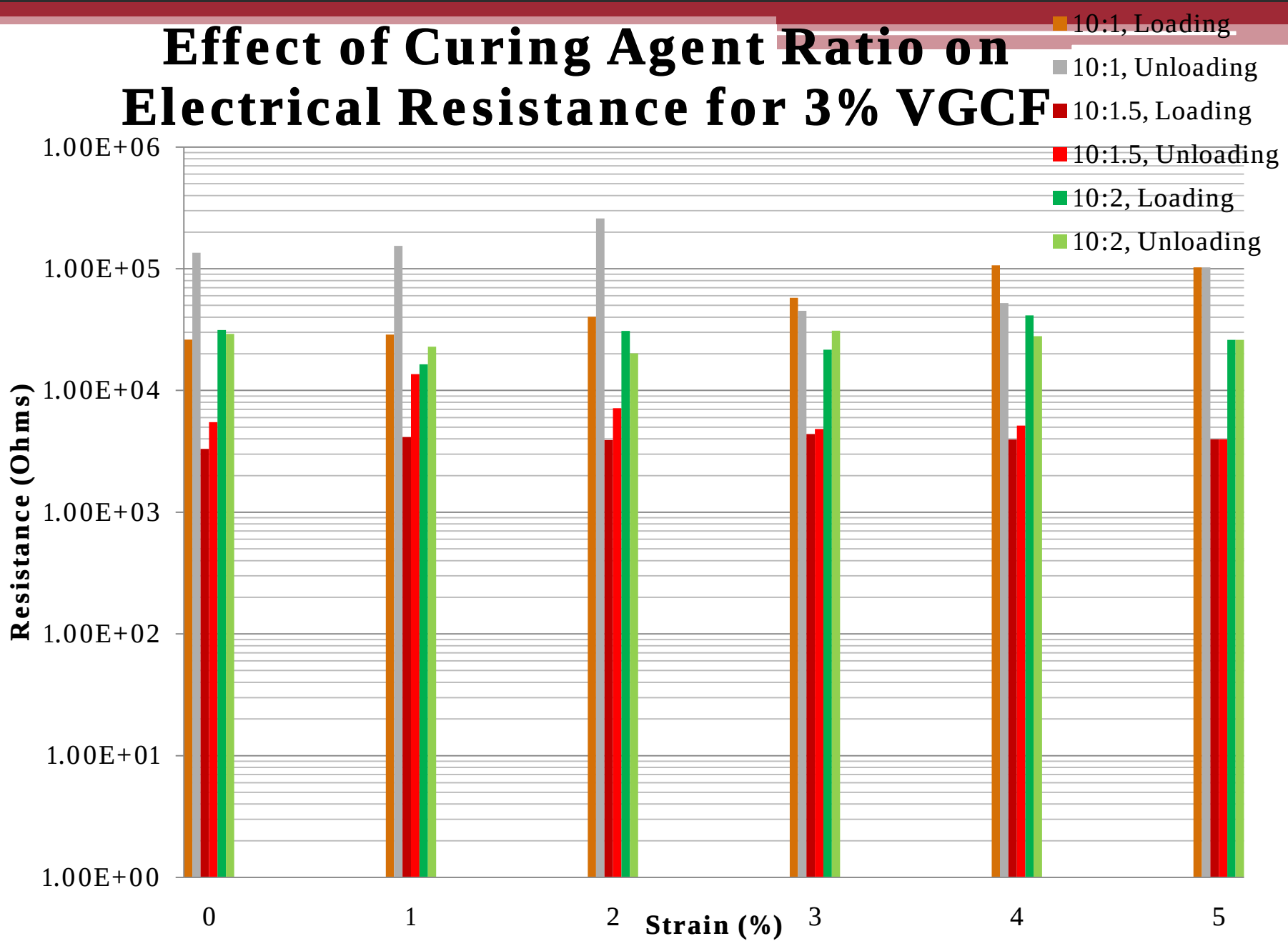
Tensile Modulus Data



Effect of VGCF concentration on Electrical Resistance For 10:1 Monomer:Curing Agent Ratio



Effect of Curing Agent Ratio on Electrical Resistance for 3% VGCF



Conclusions

- Higher ratios show better recovery of conductivity upon unloading
- Long term trends need to be tested
  - Initial stain may cause a fundamental change in fiber alignment.
  - Fatigue tests will be performed
- Compare fiber alignment hypothesis with SEM images.
- Formulate a quantifiable calibration curve

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Questions???